IN THE SPECIFICATION:

Please amend paragraph **[0005]** as follows:

[0005] Finite analysis programs that provide solutions to specific problems are commercially available. For example, ~~ABAQUS~~ ABAQUS® is available from Hibbitt, Karlsson and Sorenson, Inc., of Pawtucket, Rhode Island to model structural mechanics and nonlinear heat transfer. ~~ANSYS~~ ANSYS® is available from Ansys, ~~Inc,~~ Inc., of Canonsburg, PA to model structural mechanics and heat transfer. ASTMA is public domain software available from the National Aeronautics and Space Administration (NASA) that models heat transfer and ablation. ~~IDEAS~~ I-DEAS is available from Structural Dynamics Research Corporation of Milford, Ohio to provide pre and post-processing images of the model. SINDA from ~~SINDA, Inc. of Tempe,~~ Network Analysis, Inc., of Chandler, Arizona models heat transfer. TEX CHEM models chemical reactions and chemical equilibrium. RECESS is a program developed by Thiokol Propulsion of Brigham City, Utah to model internal ballistics. CDCA is a computational fluid dynamics program developed by Pennsylvania State University to model crack combustion where a fracture in a propellant affects burn condition. CCM is a similar computational fluid dynamics program available in the public domain, and is available from the Air Force Research Laboratory ~~(ARFL).~~ (AFRL).

Please amend paragraph **[0007]** as follows:

[0007] A problem exists in the field of finite analysis modeling because engineering specialties do not encompass a wide array of specialized problems that are presented by complex physical situations. For example, the burning of a solid fuel rocket motor presents a multifaceted problem including structural mechanics, material properties, internal ballistics, chemical reactions, heat transfer, crack combustion, and fracture mechanics. An engineer who is modeling only one of these problems using a commercially available or proprietary finite analysis program for this purpose may require a full year just to become proficient at using the package. ~~Such~~ Typically, such an engineer is ~~typically~~ not trained in more than one or two of the specialty problem areas and is often incapable of running models in areas outside his or her area of

expertise. Very few, if any, engineers succeed in acquiring the training that is required to model all aspects of this problem, and a team of modelers often is required to produce modeling results through a laborious process involving the transfer of model results between different engineers and/or finite analysis codes.

Please amend paragraph **[0011]** as follows:

[0011] Accordingly, an object of the present invention is to provide a finite analysis modeling system that permits the user to identify a joint problem for a coupled solution through the use of a graphical user interface or a scripting language.

Please amend paragraph **[0021]** as follows:

[0021] ~~A third,~~ Third, fourth, fifth or additional programs may be selected in like manner and placed in the coupled or joint program execution for convergence among all of the programs. For example, where a third program is selected for use in the coupled solution, the third program acts upon third program input values selected from the group consisting of first program output values, second program output values, and combinations ~~thereof~~ thereof, to provide third program output values. The third program output values include a third joint data set comprising input values selected from the group consisting of first program input values, second program input values and combinations thereof. The method of operation then includes executing the third program to produce the third program output values including the third joint data set. The third joint data set is provided, as needed, providing the third joint data set to the first and second finite analysis programs with corresponding input values selected from the group consisting of first program input values, second program input values and combinations thereof. Iterative threshold convergence can then be achieved according to convergence criteria specified through the graphical user interface.

Please amend paragraph **[0022]** as follows:

[0022] The software, system and method can be applied to a number of problems, for example, in the field of missile design and maintenance. For example, where a solid fuel rocket has maintenance operations performed on it, and these operations provide computed tomography results showing a crack in the propellant, the effect of this crack may be modeled to determine whether the crack will prevent the missile from completing its intended purpose if the missile is launched. In this case, the computational fluid dynamics program may be a crack combustion program, the system provides means for modeling crack combustion in a missile based upon computed tomography taken from a missile, and the other of the first and second programs is, by way of example, a structural analysis program.

Please amend paragraph **[0024]** as follows:

[0024] ~~Figure~~ FIG. 1 is a schematic diagram of a preferred system embodiment according to one aspect of the invention;

Please amend paragraph **[0026]** as follows:

[0026] FIG. 3 depicts a mid-sectional view of a rocket motor having various defects that are modeled by finite analysis causing mesh boundaries to change, in order to provide additional detail with respect to aspects of the preferred method illustrated with respect to FIG. 2;

Please amend paragraph **[0036]** as follows:

[0036] FIG. 2 is a block diagram of a process 200 representing the operation of system 100. Step 202 entails using the GUI 110 to identify a problem for a coupled solution between two or more of the programs shown in RAM blocks 112-118. Data linkages, as well as a sequence of operation for the respective programs to solve a coupled solution, have been previously entered by an expert or team of experts in coupling the finite analytical programs.

Please amend paragraph **[0037]** as follows:

[0037] Data for these solutions is provided to the system 100 in step 204 where, for example, computed tomography data from missile maintenance operations may be provided as input for a structural model. Additional data including such data as materials properties; the specification of materials; boundary conditions of temperature, pressure, force, and any other useful data, is provided as needed by the specific analytical programs. A mesh generator program, such as the fifth <u>finite analysis</u> program 120 or a plurality of such programs designed for specific applications, is also used to provide data input in the form of mesh generation.

Please amend paragraph **[0038]** as follows:

[0038] Step 206 preferably begins once the data input of step 204 is concluded, as shown in FIG. 2, but the process 200 may also interrupt itself to ask the user for input at any time. The first <u>finite analysis</u> program is executed in a sequence of execution designed by the expert or team of experts. The execution of the first program in step 206 provides first program output including a joint data set that may be shared, in step 208, as input data with the second finite analysis program shown in block 114. Additional data subsets may be generated and shared with any other of the finite analysis programs in blocks 116 and 118, for example. The second finite analysis program is executed in step 210 with a similar sharing of data in step 212. In step 212, however, the second program output may provide a second joint subset of data that can be used as input data for the first program once step 206 is executed again. The remaining <u>finite analysis</u> programs are executed in a similar manner with appropriate data linkages being provided in cooperation with <u>an</u> executable code associated with the GUI 110 so that the user does not need to specify data linkages to obtain a coupled solution.

Please amend paragraph **[0039]** as follows:

[0039] In preferred embodiments, a portion of the data input in step 204 includes a criterion or criteria for iterative threshold convergence. For example, where the ballistics block 118 produces pressure data that modifies the program input for the structural block 114

due to the elastic deformation of rocket propellant, the initial boundary condition of pressure in the structural block 114 may be modified with time, as may the pressure conditions of the computational fluid dynamics model 112. The change in pressure from the ballistics model causes the structural volume results to change, as computed by the structural block 114. In turn, the computational results from the structural block ~~114~~ 114, including an altered ~~volume~~ volume, may be supplied as input to the computational fluid dynamics block 112 to obtain still different pressures. Both the volume results from structural block 114 and the pressure results from the computational fluid dynamics block 112 may, in turn, be supplied as input to the ballistics block 118.

Please amend paragraph **[0040]** as follows:

[0040] In step 216, this iterative procedure continues with repetitive iterations through steps 206, 208, 210, 212, and 214 until the specified convergence criteria or a maximum number of iterations representing a probable divergent solution is achieved. For example, the user-specified convergence criteria may indicate convergence when the total pressure change for computations in the ballistics block 118 is less than a fixed value, e.g., one-half psi between successive iterations; when the volume change in successive iterations through the structural block 114 is less than a predetermined delimiting percentage of the total volume; when calculations for the same value obtained as output from different programs match within a delimiting percentage; combinations of these examples; and any other useful convergence criteria.

Please amend paragraph **[0042]** as follows:

[0042] Step 220 entails the interpolation or projection of meshes for reasons that are illustrated, by way of example, in FIG. 3. In summary, mesh boundaries frequently move as a result of physical responses to system stimuli, e.g., heat, pressure, strain, and ablation, so that the model boundaries must be adjusted due to these movements. FIG. 3 depicts a section 300 of an aging cylindrical solid fuel rocket motor. The motor includes a composite outer shell 302, a

liner 304 that is used to protect the outer shell from burn-through during launch, an inner core 306 of visco-elastic rocket propellant, and an interior core 308 comprising a burn chamber. Conventional maintenance operations including computed tomography have diagnosed ~~an~~ a debond area 310 ~~of debonding~~ between the inner core 306 and the liner 304. Computed tomography has also diagnosed a crack 312 that is growing in the aging rocket propellant. Finite modeling has provided a coupled solution involving internal ballistics, structural, and computational fluid dynamics to demonstrate various flow regimes including regimes 314, 316, 318, 320, and 322. A few rocket motors have been known to explode due to cracking of the propellant as shown in crack 312.

Please amend paragraph **[0043]** as follows:

[0043] The propellant region 324 tends to deform more readily due to higher velocity downstream of crack 312, which results in a higher upstream pressure. Flow conditions around the crack 312 have a ~~Bernouli~~ Bernoulli effect that results in decreased pressure in flow regime 320 downstream of the crack 312. The regime 320 narrows the flow through regimes 316 and 318, and imparts increased velocity. Flow regime 322 is a relatively low pressure flow regime. Another potential problem is that the inner core 306 may strip away from the debond area 310 with disastrous results.

Please amend paragraph **[0044]** as follows:

[0044] The computational fluid dynamics model begins calculation using a cylindrical mesh (not shown in FIG. 3) having an outer radius equal to the inside diameter of the inner core 306. This cutter radius is shown as lines 334 and 336 in FIG. 3. As shown in FIG. 3, the computational results from a first pass iteration of the coupled programs, which moved the inner diameter of the inner core 306 out to lines 326 and 328, primarily due to deformation of the inner core 306. Convergence has not yet been achieved, so it becomes necessary to adjust the associated meshes and relevant boundary conditions to account for the deformation of inner core 306. Boundary condition projection is performed by projecting the results from the fluid

mesh at lines 326 and 328 to new boundaries at lines 330 and 332. Pressure results for computational fluid dynamics (CFD), for example, may be projected to new boundaries of the structural mesh at lines 330 and 332.

Please amend paragraph **[0048]** as follows:

[0048] As mentioned above, the software and the method, as well as the computer system in an electronically programmed state, all utilize a graphical user interface that is operable to identify a joint problem that both the first and second finite analysis programs can jointly and in combination solve, and to specify at least one criterion for a joint solution. Data processing linkages between the first and second finite analysis programs, and the user, can provide the first program input values to the first program. Embedded commands in the graphical user interface or related programs execute the first finite analysis program to obtain the first program output values, including the first joint data set. Data processing linkages between the first and second finite analysis programs then can provide the second finite analysis program with second program input values including the first joint data set. Embedded commands in the graphical user interface, related programs, or a scripting language can be used to execute the second finite analysis program to provide second program output values including the second joint data set. Data processing linkages between the first and second finite analysis programs then provide the first finite analysis program with first program input values, including the second joint data set.

Please amend paragraph **[0049]** as follows:

[0049] FIG. 4 depicts a plurality of graphical fields such as may appear, for example, on the cathode ray tube (CRT) display panel of a user who is interacting with the graphical user interface of the preferred embodiment. The graphical elements are also known as fields, and may be accessed, for example, by clicking the button of a mouse to reveal additional menu options or icons that are associated with each field.

Please amend paragraph **[0060]** as follows:

[0060] The new surface area and mesh is supplied to a computational fluid dynamics and/or ballistics program as program input data in step 514. Iteration continues along loop 516 until convergence is achieved and performance data is supplied in step 518. The computational fluid dynamics program that is used in step 514 may be configured to provide a ~~three dimensional~~ three-dimensional transient solution that has not been previously done in the art. For example, a special scripting language may be used to provide threshold convergence of the solution at small time steps with sequential performance data being provided in step 516 for each time step. Computations of this type may require several CPU weeks to complete, even where the processor is operating in the gigahertz range of clock speeds, and the manual intervention that would have been required to couple the programs for this type of solution was simply impossible using prior methods.

Please amend paragraph **[0063]** as follows:

[0063] Prior mention has been made of a scripting language. The scripting language permits advanced users or system experts to issue program commands that are comparable in analogy to function calls from an object-oriented programming language. A particularly preferred scripting language is Python, ~~which is a copyrighted~~ a copyrighted, but freely usable and distributable product, even available for commercial ~~use, and is available~~ use from ~~PythonLabs~~ the Python Software Foundation at www.python.org.

Please amend paragraph **[0064]** as follows:

[0064] The Python scripting language is often compared to other object-oriented programming languages including Tcl, Perl, Scheme or Java, which may provide object oriented substitutes for Python. According to a presently contemplated but merely illustrative embodiment of the invention, the executable code supporting the GUI 400 is written in Python scripting language by an expert in one or more of the finite element analytical programs. An ~~expert~~ "expert" is hereby defined as a person who has at least five hundred hours of training and program use in a particular finite analysis program, and this time of use is preferably more than one thousand hours.